

Proportionate Mortality Among US Migrant and Seasonal Farmworkers in Twenty-Four States

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Background US migrant and seasonal farmworkers may be exposed to potentially carcinogenic pesticides and other agents. Little epidemiologic research has been conducted on this population.

Methods We examined the proportionate mortality of 26,148 subjects (14,631 white men (WM), 7,299 nonwhite men (NM), 1,081 white women (WW), and 3,137 nonwhite women (NW)) who were identified as farmworkers on death certificates from 24 US states during 1984–1993.

Results Farmworkers had significantly elevated proportionate mortality from injuries, tuberculosis, mental disorders, cerebrovascular disease, respiratory diseases, ulcers, hypertension (NW), and cirrhosis (NW). There was significantly reduced mortality from infectious diseases (other than tuberculosis), endocrine disorders, nervous system diseases, pneumoconioses, arteriosclerotic heart disease (WM), and all cancers combined. Proportionate cancer mortality analyses found excess cancers of the buccal cavity, larynx, esophagus, stomach, skin (NW), and cervix, and deficits for cancers of the colon, breast, kidney, pancreas (NW), and lymphohematopoietic system.

Conclusions The excess deaths from injuries, respiratory disease, and stomach cancer, and the deficits of colon cancer and arteriosclerotic heart disease among farmworkers, are consistent with typical mortality patterns previously observed among farm owner/operators. The excess buccal, laryngeal, esophageal, and cervical cancers, and the deficits of breast cancer and lymphohematopoietic cancers have not generally been observed in studies of farm owner/operators. *Am. J. Ind. Med.* 40:604–611, 2001.

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INTRODUCTION

In the US, the agricultural population consists of approximately 2 million farm owner/operators, 6 million farm family members, and 3–5 million hired migrant and seasonal farmworkers. Farmers and farmworkers have many similar exposures, such as pesticides, fertilizers, fuels and oils, engine exhaust, dusts, zoonotic microbes, sunlight, and hard physical labor. Farmworkers, however, face some

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agriculturally-related exposures and other living conditions that may not be shared by farmers, such as inadequate housing, lack of adequate drinking water, lack of toilet facilities in the field, lack of bathing and laundry facilities, extensive motor vehicle travel, poor nutrition, lack of refrigeration, lack of access to medical care, and lack of day care [Meister, 1991]. Farmworkers usually live in extreme poverty as they travel through the US to plant, weed, thin, harvest, and pack crops. Farmworker children often begin field work at a young age, when susceptibility to carcinogens may be great.

Recent reviews of epidemiologic research on farmers cite dozens of studies on cancer [Blair and Zahm, 1991; Blair et al., 1992; Zahm et al., 1997]. In contrast, there has been little epidemiologic research on farmworkers, particularly for cancer [Zahm et al., 1997]. In 1990, a review of 24 years of medical literature found no studies on cancer among migrant farmworkers [Rust, 1990]. A 1993 review [Zahm and Blair, 1993] cited 11 reports containing information on cancer among US and Canadian migrant farmworkers, but most were general occupational mortality studies in which farmwork was just one of a large number of job titles evaluated. There were very few studies that focused specifically on cancer among farmworkers and none of that had detailed information on farmwork activities or exposures.

Given the paucity of data on cancer and other causes of mortality among farmworkers, we conducted a proportionate mortality study of farmworkers using death certificates from 24 US states that had previously been coded for occupation and industry.

MATERIALS AND METHODS

In 1984, the National Cancer Institute (NCI), the National Institute for Occupational Safety and Health (NIOSH), and the National Center for Health Statistics (NCHS) began supporting the coding of occupation and industry titles [US Department of Commerce, 1982] on death certificates from 24 US states (Table I). This study is based on deaths that occurred in these 24 states during 1984–1993. The years of participation varied by state with 12 states participating for the entire 10-year period. The following death certificate data were utilized for each subject: usual occupation, race, gender, age at death, underlying cause of death, and state of death. The states were grouped into five geographic regions (Table I).

Subjects were decedents whose usual occupation according to the death certificate was farmworker (code 479). Farmers (code 473) were not included in this study. However, Blair et al. [1993] conducted a similar study of farmers in this database, and the findings from that study are compared to the findings for farmworkers in this paper. Farm supervisors (code 476) were also excluded from this study.

TABLE I. Distribution of 26,148 Farmworker Deaths in 24 States by Race, Gender, and Geographic Region, 1984–1993

Region	WM	NM	WW	NW
Northeast ^a	1,379	107	122	52
North central ^b	2,686	147	264	39
South central ^c	2,521	213	77	28
Southeast ^d	3,387	6,785	374	3,006
West ^e	4,658	47	244	12
Total	14,631	7,299	1,081	3,137

^aNortheast: Maine, New Hampshire, New Jersey, Rhode Island, Vermont.

^bNorth central: Indiana, Ohio, Wisconsin.

^cSouth central: Kansas, Missouri, Nebraska, Oklahoma.

^dSoutheast: Georgia, Kentucky, North Carolina, South Carolina, Tennessee, West Virginia.

^eWest: Colorado, Idaho, Nevada, New Mexico, Utah, Washington.

Proportionate mortality ratios (PMRs) and proportionate cancer mortality ratios (PCMRs) were calculated for white (Hispanic and non-Hispanic) men (WM), nonwhite men (NM), white women (WW), and nonwhite women (NW) using the O/E System, an analytic software package developed by the NCI [Dosemeci et al., 1992]. The information on ethnicity in the database was not consistently available from state to state and was not sufficiently reliable to allow us to separate whites into Hispanics versus non-Hispanics. Race- and gender-specific age-adjusted (5-year age groups) expected numbers of deaths were based on the proportionate mortality experience of all decedents in the 24 states during the study period. For analyses by geographic region, expected numbers were based on the decedents of the geographic region being considered. Ninety-five percent confidence intervals (CI) were calculated according to the method described by Liddell [1984].

RESULTS

There were 26,148 deaths among farmworkers in the 24 states during 1984–1993 (Table I). A total of 14,631 (56%) farmworker deaths occurred among WM, 7,299 (28%) among NM, 1,081 (4%) among WW, and 3,137 (12%) among NW. The southeastern states accounted for over half of the deaths overall and 94% of the deaths among nonwhites.

Table II presents the race- and gender-specific PMRs for broad categories of cause of death. Significant deficits were observed for mortality from infectious diseases and AIDS, endocrine disorders and diabetes, nervous system disorders and multiple sclerosis, pneumoconiosis, and all cancers combined (the number of deaths were small for multiple sclerosis (3) and pneumoconiosis (5)). White male farmworkers experienced a slight deficit in mortality from arteriosclerotic heart disease; this deficit was significant only in the western states (deaths = 1,018, PMR = 85,

TABLE II. Number of Farmworker Deaths and PMRs for Broad Categories of Cause of Death by Race and Gender in 24 States, 1984 – 1993

Cause of death	WM			NM			WW			NW			Total		
	No.	PMR (CI) ^a	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)	No.
Infectious diseases	231	62 (55–71)	235	62 (54–70)	12	64 (33–112)	74	72 (57–90)	552	63 (58–69)					
Tuberculosis	15	163 (91–269)	34	178 (123–248)	1	180 (2–1000)	6	119 (43–259)	56	165 (125–214)					
AIDS	53	27 (20–35)	92	40 (32–49)	2	61 (7–219)	18	60 (36–95)	165	36 (30–41)					
Malignant neoplasms	2628	79 (76–82)	1538	87 (83–91)	248	90 (79–102)	466	75 (68–82)	4880	81 (79–84)					
Endocrine, metabolic, and immune diseases	346	97 (87–108)	197	81 (70–93)	35	90 (63–125)	169	94 (80–109)	747	91 (85–98)					
Diabetes	250	97 (86–110)	128	72 (60–86)	26	91 (60–134)	130	92 (77–110)	534	88 (81–96)					
Mental and psychoneurotic disorders	255	146 (129–165)	176	127 (109–147)	14	93 (51–157)	76	168 (132–210)	521	139 (128–152)					
Nervous system diseases	215	81 (71–93)	74	85 (67–107)	16	66 (38–108)	39	93 (66–127)	344	83 (74–92)					
Multiple sclerosis	3	32 (6–94)	1	41 (1–225)	0	0 (0–193)	1	45 (1–251)	5	31 (10–73)					
Circulatory system diseases	5773	96 (94–99)	2987	106 (102–109)	421	94 (85–104)	1660	108 (103–114)	10841	100 (99–102)					
Hypertension	118	85 (71–102)	191	91 (78–104)	18	122 (72–193)	160	124 (105–144)	487	99 (90–108)					
Arteriosclerotic heart disease	3646	95 (92–98)	1450	101 (96–107)	233	96 (84–109)	730	102 (95–110)	6059	97 (95–100)					
Cerebrovascular disease	808	105 (98–113)	620	124 (115–134)	77	91 (72–114)	411	126 (114–139)	1916	114 (109–119)					
Respiratory diseases	1686	124 (118–130)	560	111 (102–121)	112	124 (102–149)	162	93 (79–108)	2520	119 (114–123)					
Pneumonia	609	119 (110–129)	283	120 (106–135)	29	76 (51–109)	109	108 (88–130)	1030	116 (109–123)					
Emphysema	148	117 (99–138)	24	77 (49–114)	11	160 (80–286)	2	40 (4–144)	185	109 (94–126)					
Pneumoconioses	5	30 (10–71)	1	17 (0–96)	0	0 (0–8000)	0	0 (0–3178)	6	27 (10–58)					
Digestive system disorders	541	114 (105–124)	236	89 (78–101)	34	88 (61–123)	119	110 (91–131)	930	105 (98–112)					
Gastric and duodenal ulcer	49	131 (97–173)	19	111 (67–173)	5	167 (54–390)	9	141 (64–268)	82	128 (102–159)					
Cirrhosis	187	102 (88–118)	99	95 (78–116)	7	67 (27–138)	40	150 (107–205)	333	103 (92–114)					
Genitourinary system disorders	260	114 (100–129)	192	100 (87–116)	23	117 (74–176)	130	114 (95–135)	605	109 (101–118)					
Diseases of skin and cellular tissue	17	118 (69–190)	16	73 (42–119)	4	236 (63–604)	28	148 (98–214)	65	115 (88–146)					
Symptoms, senility, and ill defined conditions	163	117 (100–136)	98	100 (81–122)	12	111 (57–193)	44	124 (90–166)	317	112 (100–125)					
External causes	2431	133 (127–138)	916	132 (123–140)	135	159 (133–188)	134	124 (104–147)	3616	133 (129–137)					

^aPMR (CI) = Age adjusted proportionate mortality ratio (95% confidence interval).

CI = 80–90). WM had a significant deficit in mortality from hypertensive disease in the south central states (deaths = 11, PMR = 45, CI = 23–81). Nonwhites had significantly elevated mortality from cerebrovascular disease in the southeast (NM: deaths = 580, PMR = 126, CI = 116–137; NW: deaths = 402, PMR = 129, CI = 117–143), and NW also had significantly increased mortality from hypertension. Significant excesses were observed for deaths due to tuberculosis, particularly among males in the southeastern region (WM: deaths = 6, PMR = 296, CI = 108–645; NM: deaths = 32, PMR = 179, CI = 123–253), mental and psychoneurotic disorders, respiratory diseases and pneumonia, gastric and duodenal ulcers, cirrhosis among NW, and external causes.

Among external causes of death, total injuries, motor vehicle injuries, and other unintentional trauma were elevated in all race-gender groups (Table III). Unintentional poisonings were significantly elevated among males, and falls were elevated almost three-fold among WW. Homicides were elevated among whites but not among nonwhites. Suicide was significantly decreased among men but was nonsignificantly elevated among women. Deaths from firearms were significantly elevated among WW and significantly reduced among NM.

A significant deficit in proportionate cancer mortality due to colon cancer was observed among farmworkers (Table IV). The deficit was most pronounced for men, particularly in the southeastern states (WM: deaths = 31, PCMR = 61, CI = 41–86; NM: deaths = 81, PCMR = 75, CI = 59–93); WM also had a significant deficit in rectal cancer in the southeast (deaths = 31, PCMR = 61, CI = 41–86). Colon cancer mortality was nonsignificantly elevated among WW, particularly in the northeastern states (deaths = 5, PCMR = 181, CI = 58–423). Male farmworkers experienced a significant deficit of deaths due to kidney cancer; this excess was not observed in women, although the number of deaths from kidney cancer among women ($n = 13$) was small. WW experienced a significant deficit in deaths from brain cancer, and NW had a significant deficit from pancreatic cancer. Deaths from lymphohematopoietic cancers were underrepresented among farmworkers, particularly among NM, who experienced a deficit in these cancers in every region of the US. Female farmworkers had fewer deaths than expected from breast cancer.

Farmworkers had significantly elevated mortality from cancer of the larynx; this association was particularly strong among WM in the southeast (deaths = 13, PMR = 223, CI = 118–381). Stomach cancer was also significantly elevated in farmworkers, particularly among white males in the western region (deaths = 49, PMR = 219, CI = 162–290). Nonwhites also had significant excesses of cancers of the buccal cavity and pharynx and esophagus. Melanoma was elevated among nonwhites but not among whites. All deaths from melanoma among NW occurred in the south-

east. Skin cancer displayed a similar pattern. There were three deaths from lip cancer among WM, two in the southeastern region and one in the south central region, and none among the other groups. Women experienced a significant excess in cervical cancer, particularly in the southeast (WW: deaths = 6, PCMR = 300, CI = 110–654; NW: deaths = 31, PCMR = 182, CI = 124–259) and northeast (WW: deaths = 4, PCMR = 540, CI = 145–1382). WM had elevated mortality from testicular cancer, and the increase was significant in farmworkers under age 40 (deaths = 9, PCMR = 255, CI = 116–484). Testicular cancer was the only cancer with a significant increase in this age group.

DISCUSSION

In this study, the PMR method was used to examine causes of death among farmworkers in 24 states. This study has several limitations which may lead to biased risk estimates. In the PMR methodology, a true excess in one disease must be compensated for by an artificial deficit in another disease(s). Because farmworkers appear to have absolute excesses in deaths from injuries and some cancers, other causes of death may appear low even if they occur more frequently in farmworkers than in the general population. Another obvious limitation of this study is the inaccuracy in coding of occupation and cause of death on death certificates; the latter is evident from farmworkers' excess mortality due to symptoms, senility, and ill-defined conditions. These coding errors would tend to bias risk estimates towards the null [Checkoway et al., 1989]. Dilution of the risk estimate also results from the lack of information on individual variations in exposure due to differences in tasks that farmworkers perform, crops that they work with, and duration of employment. Overall, mortality risks are more likely to be underestimated than overestimated because the dilution effects caused by misclassification of disease and occupation, and lack of individual exposure information, are more severe than the enhancing associated with the PMR method [Blair et al., 1993].

It is important to understand that this analysis reflects the mortality experience of generally younger people actively engaged in farmwork. Texas, California, and Florida, the three states in which most farmworkers live when they are not migrating, are not included in the database; thus, most of the deaths in the database are likely to have occurred away from home. Moreover, farmworkers who die at older ages are likely to have retired from farmwork long ago and are therefore unlikely to have "farmworker" listed as the usual occupation on their death certificate. As a result, the PMR analysis most adequately reflects causes of death among young farmworkers and from proximate causes, as evidenced by the elevated mortality from motor vehicle and

TABLE III. Number of Farmworker Deaths and PMRs for External Causes of Death by Race and Gender

Cause of death	WM		NM		WW		NW		Total	
	No.	PMR (CI) ^a	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)	No.	PMR (CI)
External causes	2431	133 (127–138)	916	132 (123–140)	135	159 (133–188)	134	124 (104–147)	3616	133 (129–13)
All injuries	1643	147 (140–154)	629	167 (155–181)	94	166 (134–203)	99	136 (111–166)	2465	152 (146–15)
Motor vehicle injuries	938	145 (136–155)	255	156 (137–176)	65	183 (141–233)	41	168 (120–227)	1299	149 (141–15)
Other (nontransport)	656	154 (142–166)	349	173 (156–192)	29	146 (97–209)	57	120 (91–156)	1091	157 (148–16)
unintentional trauma										
Unintentional poisonings	29	152 (102–218)	29	269 (180–386)	0	0 (0–614)	3	188 (38–551)	61	190 (145–24)
Falls	42	110 (80–149)	20	131 (80–202)	8	277 (119–545)	2	38 (4–139)	72	117 (92–148)
Suicide	409	79 (71–87)	49	69 (51–92)	25	150 (97–221)	7	118 (47–243)	490	80 (73–87)
Homicide	337	218 (196–243)	230	98 (86–111)	14	145 (79–243)	26	94 (61–138)	607	142 (131–15)
Firearms	501	104 (95–114)	178	82 (71–96)	26	185 (121–271)	16	93 (53–151)	721	99 (92–107)

^aPMR (CI) = Age adjusted proportionate mortality ratio (95% confidence interval).

other injuries. Farmwork-related diseases with long latency periods that tend to appear later in life, such as cancer, are less likely to be found to be elevated in farmworkers in this analysis.

There were many similarities in the mortality patterns observed between the farmworkers from 24 US states and farm owner/operators in recent reviews, but there were numerous differences as well. Recent reviews of mortality and morbidity patterns among farmers found them to be at decreased risk for total mortality, arteriosclerotic heart disease, all cancer, and cancers of the colon, esophagus, lung, bladder, and liver. Farmers were reported to be at increased risk of death from external causes, respiratory disease, melanoma and non-melanoma skin cancer, cancers of the lip, stomach, prostate, brain, testes, and connective tissue, and lymphohematopoietic cancers (leukemia, Hodgkin's disease, non-Hodgkin's lymphoma, and multiple myeloma) [Blair and Zahm, 1991; Blair et al., 1992; Zahm et al., 1997].

Like farmers, farmworkers experienced decreased mortality from all cancer combined and from colon cancer, and deaths from arteriosclerotic heart disease were slightly lower than in the general population. This is possibly due to relatively high levels of physical activity in these two occupational groups. However, unlike farmers, farmworkers were not at lower risk for dying from esophageal, lung, liver, or bladder cancer. Deficits in these cancers among farmers have been attributed to lower rates of smoking and alcohol consumption relative to the general population [Blair and Zahm, 1991; Blair et al., 1992; Zahm et al., 1997]. Apparently, these behaviors are not similarly reduced in farmworkers. Mortality patterns among farmworkers are suggestive of elevated alcohol consumption, as evidenced by excess deaths from cancers of the buccal cavity and pharynx, larynx, and esophagus. Significant excesses in cancers of the buccal cavity and pharynx and the esophagus occurred only in nonwhites; NW also had significantly increased mortality from cirrhosis of the liver. Although esophageal cancer can be related to smoking as well as alcohol, other smoking-related diseases (e.g., emphysema, lung cancer, and bladder cancer) were not elevated among nonwhites. Emphysema, lung cancer, and bladder cancer were elevated in WW, although not significantly so. White male farmworkers had a significant excess in laryngeal cancer mortality, contrary to what was observed for white male farmers in this database [Blair et al., 1993].

Similar to farmers, farmworkers had excess mortality from stomach cancer. In addition, farmworkers in the 24 states had significantly more deaths from gastric ulcers than the general population. Infection with *Helicobacter pylori* is a known cause of gastric ulcers and is suspected of being a risk factor for stomach cancer as well [Neugut et al., 1996; Munoz and Franceschi, 1997]. Stomach cancer risk may also be related to socioeconomic status, nutrition, availability of

TABLE IV. Number of Farmworker Deaths and PCMRs by Race and Gender

Cancer	WM		NM		WW		NW		Total	
	No.	PCMR (CI) ^a	No.	PCMR (CI)	No.	PCMR (CI)	No.	PCMR (CI)	No.	PCMR (CI)
Buccal cavity and pharynx	43	90 (65–122)	68	153 (119–194)	3	115 (23–335)	12	204 (105–357)	126	125 (105–149)
Esophagus	56	92 (69–119)	96	133 (107–162)	2	102 (11–370)	17	186 (108–297)	171	118 (101–137)
Stomach	97	138 (112–169)	70	108 (85–137)	1	22 (0–124)	23	132 (84–198)	191	122 (105–141)
Colon	210	87 (75–99)	84	72 (57–89)	28	118 (79–171)	43	76 (55–103)	365	83 (75–92)
Rectum	29	71 (48–102)	21	104 (64–159)	2	60 (7–218)	6	84 (31–183)	58	81 (62–105)
Liver	70	122 (95–154)	23	71 (45–107)	4	73 (20–186)	10	92 (44–169)	107	101 (82–122)
Pancreas	129	112 (93–133)	61	89 (68–114)	10	84 (40–154)	20	64 (39–99)	220	97 (84–110)
Larynx	43	163 (118–220)	26	107 (70–157)	1	128 (2–714)	3	175 (35–511)	73	137 (108–173)
Lung	889	101 (94–107)	531	106 (97–116)	67	124 (96–1570)	59	79 (60–102)	1546	102 (97–107)
Skin	58	97 (74–125)	14	143 (78–240)	2	47 (5–170)	7	266 (107–549)	81	106 (84–132)
Lip	3	362 (73–1059)	0	0 (0–6594)	0	0 (0–14041)	0	0 (0–19578)	3	323 (65–944)
Melanoma	33	76 (52–106)	6	297 (109–647)	1	29 (0–160)	3	229 (46–668)	43	85 (62–115)
Breast	3	105 (21–306)	2	98 (11–355)	40	82 (58–111)	67	82 (63–104)	112	82 (68–99)
Cervix					13	229 (122–392)	32	181 (124–256)	45	193 (141–258)
Uterus					7	121 (49–249)	23	129 (82–194)	30	127 (86–182)
Prostate	297	94 (83–105)	291	103 (92–116)					588	98 (90–107)
Testes	12	167 (86–292)	2	80 (9–288)					14	145 (79–243)
Bladder	86	115 (92–142)	19	81 (49–127)	5	174 (56–407)	5	62 (20–145)	115	105 (87–126)
Kidney	42	67 (48–90)	15	58 (32–95)	5	117 (38–272)	8	124 (53–243)	70	70 (55–89)
Brain	58	90 (69–117)	10	73 (35–134)	1	15 (0–86)	5	104 (33–242)	74	83 (65–104)
Soft tissue sarcoma	13	81 (43–139)	4	68 (18–175)	0	0 (0–195)	4	100 (27–256)	21	76 (47–116)
All lymphohematopoietic	253	95 (83–107)	67	63 (49–81)	25	105 (68–155)	39	96 (68–132)	384	88 (79–97)
Non Hodgkin's lymphoma	80	82 (65–102)	13	50 (27–85)	12	127 (65–221)	9	98 (45–186)	114	80 (66–96)
Hodgkin's disease	5	46 (15–108)	2	71 (8–256)	2	243 (27–876)	0	0 (0–363)	9	58 (27–110)
Multiple myeloma	48	113 (83–150)	19	52 (31–82)	4	98 (26–250)	19	122 (73–190)	90	91 (73–112)
Leukemia	108	105 (86–127)	30	82 (55–116)	7	83 (33–172)	9	68 (31–129)	154	96 (81–112)

^aPCMR(CI) = Age adjusted proportionate cancer mortality ratio (95% confidence interval).

refrigeration, exposure to nitrates from food or drinking water, and exposure to pesticides [Blair and Zahm, 1991; Blair et al., 1992; Neugut et al., 1996; Munoz and Franceschi, 1997]. Elevated mortality from lip cancer among white male farmworkers has also been observed among farmers and is likely attributable to sun exposure. For the other sun-related cancers—melanoma and skin cancer—our database had insufficient numbers of deaths for women, but among men these cancers were elevated only in nonwhites. Among whites, the PMRs for melanoma and skin cancer are difficult to interpret because of differences in the ethnic composition of white farmworkers and whites in the general population. The white farmworker population is composed of a much higher proportion of Hispanics than the general population, and it is possible that the increased pigmentation associated with Hispanic ethnicity partially ameliorates the effects of the farmworkers' high sun exposures.

Several of the cancers that were typically increased in studies of farmers were not elevated for farmworkers. The lack of an observed excess in prostate cancer, a disease primarily of older men, is probably related to the age structure of the farmworkers in the 24-state database. Farmwork is a physically demanding occupation dominated by the young [Mines et al., 1997]. As farmworkers age, they tend to switch to other, less physically demanding occupations and ultimately retire, and are unlikely to have "farmworker" listed as the usual occupation on their death certificate. Such a prostate cancer death would be counted in the comparison population rather than in the farmworker population, and the effect would be to dilute the PMR for this disease.

Other cancers that were typically elevated in studies of farmers, but not in our study, were cancers of the lymphohematopoietic system, brain, and connective tissue. PCMRs for all lymphohematopoietic cancers combined were below 100 for most of the farmworker groups in our study, and for NM the deficits were significant for non-Hodgkin's lymphoma and multiple myeloma. These findings differ significantly from those for farmers in the same database. Elevated mortality from the lymphohematopoietic cancers, brain cancer, and connective tissue cancer among farmers has been hypothesized to be pesticide-related [Blair and Zahm, 1991; Blair et al., 1992; Zahm et al., 1997]. Perhaps farmworkers in this database were less exposed to pesticides than farmers because, years ago, farmers typically applied the pesticides themselves, whereas farmworkers usually entered the fields some time later. Perhaps farmworkers work with different types of crops and are therefore exposed to different pesticides. Farmers in studies to date have generally worked with grains which involves heavy herbicide use, whereas farmworkers work with fruits and vegetables and are exposed to a greater variety of pesticides, most often insecticides. However, farmworkers are unlikely

to be less exposed to pesticides than the general population, making it difficult to explain the deficit in lymphohematopoietic cancers.

The 24-state database provided the opportunity to examine causes of death among women, who were not extensively covered in previous studies. Female farmworkers were found to have reduced mortality from breast cancer compared to the general population. The deficit for nonwhite female farmworkers was similar to nonwhite female farmers in the same database and is possibly linked to behavioral factors such as increased physical activity as well as reproductive patterns (e.g., number of children, age at first birth). However, studies of white female farmers have not observed a reduction in breast cancer mortality [Blair et al., 1992; Blair et al., 1993]. Female farmworkers were at significantly increased risk for dying from cervical cancer, which was also observed for nonwhite farmers but not for white farmers in this database. Elevated mortality from this preventable disease is likely related to poor access to medical care in this population, which is also true for some other diseases (e.g., tuberculosis and pneumonia) which are elevated among farmworkers. This indicates a need for improved public health control measures and increased access to diagnostic and medical care in this population.

Suicide deaths were significantly reduced for male farmworkers, in contrast to findings for white male farmers in the same database and to other reports of high suicide rates among farmers [Walrath et al., 1985; Stallones, 1990; Gunderson et al., 1993]. On the other hand, deaths from mental, psychoneurotic, and personality disorders were significantly elevated among male farmworkers. Perhaps differential reporting practices are responsible for the opposite pattern in suicide versus mental disorders observed among male farmworkers. It is possible that for religious or other reasons, women make sure that their male relatives' suicide deaths are not certified as such. Elevated mental and psychoneurogenic disorders might also be related to chemical exposures. A number of pesticides, particularly organophosphates, have been reported to induce chronic neurological deficits [Savage et al., 1988; Rosenstock et al., 1991; Steenland et al., 1994], although not necessarily the types of disorders observed to be elevated in this study. Deaths from nervous system disorders were reduced in this population, similar to farmers.

Injury deaths, including motor vehicle-related deaths and nontransport-related trauma, were elevated among all groups of farmworkers, a pattern consistent with farmers. Migrating and commuting to the worksite in vehicles with inadequate safety equipment may contribute to the excess in motor vehicle-related deaths, particularly among female farmworkers, who likely spend more time on the road than their counterparts in the general population. Unintentional poisonings were high in men and NW but were particularly high among NM, suggesting that workplace exposure to

hazards may be a significant problem for this group of workers. These findings might be related to actual differences in exposures or to differences in self-protective behaviors such as use of personal protective equipment during exposure to hazardous materials such as pesticides. Overall, injuries are a large problem for farmworkers and farmers, as would be expected from the circumstances of their work.

This study points out the need for improved public health education, screening, and medical treatment to reduce the occurrence of preventable and treatable diseases such as cervical cancer, tuberculosis, and pneumonia, and to reduce unnecessary or harmful exposures to pesticides and other agents. Moreover, studies need to be conducted to quantify the risks posed by farmwork and to identify the specific agents responsible for adverse health effects in order to provide effective interventions.

REFERENCES

- Blair A, Zahm S. 1991. Cancer among farmers. In: Cordes DH, Rea DF, editors. *Occupational medicine, state of the art reviews: health hazards of farming*. Philadelphia, PA: Hanley and Belfus, Inc. p 335–354.
- Blair A, Zahm SH, Pearce NE, Heineman EF, Fraumeni JF Jr. 1992. Clues to cancer etiology from studies of farmers. *Scand J Work Environ Health* 18:209–215.
- Blair A, Dosemeci M, Heineman EF. 1993. Cancer and other causes of death among male and female farmers from twenty-three states. *Am J Ind Med* 23:729–742.
- Checkoway H, Pearce NE, Crawford-Brown DJ. 1989. *Research methods in occupational epidemiology*. New York: Oxford University Press.
- Dosemeci M, Helsel W, May C. 1992. *O/E analysis command procedure for use with the 1984–1989 mortality files: users guide version 4.0*. Bethesda, MD: National Cancer Institute.
- Gunderson P, Donner D, Nashold R, Salkowicz L, Sperry S, Wittman B. 1993. The epidemiology of suicide among farm residents or workers in five North-Central states, 1980–1988. *Am J Prev Med* 9(3):26–34.
- Liddell FDK. 1984. Simple exact analysis of the standardized mortality ratio. *J Epidemiol Community Health* 38:85–88.
- Meister JS. 1991. The health of migrant farm workers. In: *Occupational medicine: state of the art reviews*, vol. 6, no. 3, July–Sept, Philadelphia: Hanley and Belfus, Inc. p 503–518.
- Mines R, Gabbard S, Steirman A. 1997. A profile of us farm workers: demographics, household composition, income and use of services. US Department of Labour.
- Munoz N, Franceschi S. 1997. Epidemiology of gastric cancer and perspectives for prevention. *Salud publica de mexico* 39:318–330.
- Neugut A, Hayek M, Howe G. 1996. Epidemiology of gastric cancer. *Semin Oncol* 23:281–291.
- Rosenstock L, Keifer M, Daniell WE, McConell R, Claypole K. 1991. Chronic central nervous system effects of acute organophosphate pesticide intoxication. *Lancet* 338:223–227.
- Rust GS. 1990. Health status of migrant farmworkers: a literature review and commentary. *Am J Public Health* 80:1213–1217.
- Savage EP, Keefe TP, Mounce LM, Lewis JA, Burcar PJ. 1988. Chronic neurological sequelae of acute organophosphate pesticide poisoning. *Arch Environ Health* 43(1):38–45.
- Stallones L. 1990. Suicide mortality among Kentucky farmers, 1979–1985. *Suicide Life Threat Behav* 20(2):156–163.
- Steenland K, Jenkins B, Ames RG, O'Malley M, Chrislip D, Russo J. 1994. Chronic neurological sequelae to organophosphate pesticide poisoning. *Am J Pub Health* 84(5):731–736.
- US Department of Commerce. 1982. 1980 census of population. Alphabetical index of industries and occupations. Washington, DC: US Government Printing Office. Publication no. PHC 80-R3.
- Walrath J, Rogot E, Murray J, Blair A. 1985. Mortality patterns among US veterans by industry and smoking status. DHHS Publication #85-2747, Washington, D.C.: U.S. Government Printing Office.
- Zahm SH, Blair A. 1993. Cancer among migrant and seasonal farmworkers: an epidemiologic review and research agenda. *Am J Ind Med* 24:753–766.
- Zahm S, Ward M, Blair A. 1997. Pesticides and cancer. In: *Occupational medicine: state of the art reviews*. Philadelphia, PA: Hanley and Belfus, Inc. 12:269–289.